

# Effect of Stylo Grass (*Stylosanthes guianensis*) Supplement on Body Mass and Forage Intake of Khari Goats in the Mid-Hills of Nepal

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## Abstract

Tree fodders are the main constituent of livestock feed, especially for goats, in mid-hills of Nepal. Stylo grass (*Stylosanthes guianensis*) is also offered to livestock, but in much smaller quantities it can ease some of the pressure on tree fodder collection for livestock. It is grown in the mid-hills of Nepal, often on marginal land, and is also intercropped with trees. In this study, goats were offered up to 5 different tree fodders including khanayo (*Ficus semicordata*), sal (*Shorea robusta*), kabro (*Ficus lacor*), katus (*Catannopsis tribuloides*) and aamp (*Mangifera indica*) and stylo grass as supplement. We predicted that stylo grass (1) would have a greater effect on body mass of goats than any of the tree fodders and (2) would reduce the intake of tree fodders. Twenty castrated local Khari goats (initial mean body mass =  $12.8 \pm 0.22$  kg), 6 to 8 months of age, were selected and divided randomly into four groups of five goats each. The groups received tree fodders *randomly* and either 0, 120, 360 or 600 g fresh matter of stylo grass for 120 days. Stylo grass and all tree fodders significantly affected final body mass. Our predictions were partially confirmed. The total dry matter intake of tree fodders was reduced with an increase in stylo grass intake, as predicted. Furthermore, stylo grass intake significantly affected body mass, also as predicted, however, its effect was less than three of the tree fodders. Stylo grass orts were similar when the goats were offered with 120 and 360 g/d fresh matter, but increased when offered with 600 g/d fresh matter. This suggests that a level of less than 600 g/d fresh matter stylo grass should be offered to grow Khari goats.

## Keywords

*Stylo Grass; Stylosanthes guianensis; Fodder Trees; Khari Goats; Mid-hills of Nepal*

## Introduction

About 70% of the total livestock in Nepal are raised in the hill region, which is mostly between 1,000 and 4,000 meters in altitude. More than 50% of Nepal's population live in this region, usually with small land holdings and, of these people, over 60% living below the poverty line (DFID, 2005). Livestock is an integral part of many subsistence households providing, in addition to income, draught power, milk, meat, fibre and manure. It generates 37% of the income of the hill people (NASA, 1991) and provides 55% of the on-farm income for small farmers (FAO, 1991). Furthermore, livestock contributes 32.3% of the total agricultural gross domestic products (Shrestha, 2005). The dominant farming system in the mid-hills of Nepal comprises three closely integrated components: crops, livestock and trees (Regmi, 2003). As expressed by Floyd *et al.*, (1999): "These components are closely linked, with the forest (trees) acting as the resource base by which crop and livestock production are sustained".

Goats are particularly important in subsistence livestock production in Nepal, and can play a significant role in improving the agricultural economy.

They are a major source of cash income for poorer Nepalese and are multipurpose animals, providing meat, hide, hair and manure. Goat meat is accepted by all ethnic groups. In addition, goats are used for sacrificial purposes at religious ceremonies and are given as gifts (*pewa*) to women. In the development of the Agriculture Prospective Plan in 1995, the goat was identified as a priority commodity and it was decided that the meat production should be increased from 3.38% of the total meat produced in 1994/95 to 7.15% by 2014/15 (Kuwar, Upreti and Pandey, 2001). However, this may be difficult to achieve because of feed shortage, mainly fodder leaves and green forage during winter (October to May). Otherwise, the cost of meat production from goats makes this enterprise non-viable (Upreti and Shrestha, 2006).

Tree fodder is the main constituent of livestock feed, especially for goats, in mid-hills of Nepal (Thapa *et al.*, 1997; Pandey *et al.*, 2009). There are more than 170 species of trees, shrubs and vines used for fodder, 40 of which are traditionally cultivated by farmers (Khanal and Subba, 2001). Fodder trees are particularly important during the dry winter which is from mid-January through mid-June, when feeds are scarce but the trees remain green and provide a nitrogen supplement to the poor quality crop remains (Thorne *et al.*, 1999; Khanal and Upreti, 2008). Trees also provide lumber, fuel, fruit and leaves for bedding of livestock and the leaves mixed with livestock waste are an important source of fertilizer for the farmers (Acharya, 2009; Rabina and Ting 2012).

Communal property, consisting of forests, degraded forests and marginal lands, and private farmlands are the major sources for tree fodder. However, due to heavy population pressure, forests are continually being reconstructed for agricultural land. In addition, forest resources and land cover are declining at a rapid rate leading to an increase in soil erosion and lowered soil fertility. The existing situation demands the rejuvenation of degraded land and the maintenance of forests which can ultimately sustain goat production in rural areas (Malla, 1996; Floyd *et al.*, 1999; Neupane, Sharma and Thapa, 2002). To accomplish these goals, Forest Users Groups have been formed to administer communal forests. These groups regulate the collection of fodder and use of the forests and are expected to invest part of the benefits to improve the forest resources (Brown *et al.*, 2002; Pokharel and Suvedi, 2007).

Such a Community Forest User Group was established at Katteldanda, a village in Ghorka. Katteldanda includes 4880 rupani (20 rupani = 1 ha) of communal land in the vicinity of the village: 4636 rupani of forest (jungle) and 244 rupani of degraded forests and/or marginal land covered by dwarf shrubs and ferns (degraded former forest areas). To rejuvenate the forest, farmers were forbidden from cutting and carrying away branches for fodder from the community forest at the time of the study. They were allowed only to graze livestock in summer and to collect leaf litter in winter; So farmers did have access to the degraded shrub area throughout the year (Degen *et al.*, 2010b).



FIG. 1 WOMEN CARRYING FODDERS TO THEIR HOUSEHOLDS

Furthermore, leaf collection was not allowed in government forests except for leaves from sal (*Shorea robusta*) trees for festive occasions such as weddings. Fodder leaves for livestock were harvested by lopping branches from trees on upland, rain-watered, private land (*bari*). Usually, women collected loads of fodder of about 30 kg each trip, however loads of more than 75 kg were also measured. The fodder loads were either placed in a basket or tied in a bundle and then secured with a belt which was placed on the forehead of the carrier, with much of the weight of the bundle on the carrier's back (Fig 1).

Introduction of forage legumes into the farming system has been suggested as one of the strategies for ensuring the sustainability of livestock and crop yields in the mid-hills of Nepal. Forage legumes not only provide quality feed for livestock but also contribute to sustaining soil fertility. Legumes have relatively high protein levels and also provide essential minerals and vitamins (Horne and Sturr, 2000). Stylo grass (*Stylosanthes guianensis*), which is often grown on marginal land in the mid-hills of Nepal and is also

intercropped with trees, can ease some of the pressure on tree fodder collection for livestock. This perennial fodder legume is a sub-shrub, semi-erect or erect, with a strong tap root and small round root nodules. Phengsavan and Phimphachanhvongsod (1997) reported that stylo 184 grew quickly and was well-adapted to a wide range of environmental conditions. Stylo grass has been used to supplement crop residues (Horne and Stur, 1999) and the macro-mineral bioavailability in grass planted with Verano-stylo legume can improve the utilization of Ca in goats (Bamikole, 2003).

In this study, local Khari goats were offered up to 5 different local tree fodders and stylo grass supplement. We hypothesized that stylo grass intake would affect (1) body mass of the goats and (2) the intake of tree fodders. We predicted that stylo grass would (1) have a greater effect on body mass of goats than any of the tree fodders and (2) reduce the intake of tree fodders.

## Materials and Methods

### Study Site and Fodder Trees

The study was conducted at Katteldana ( $28^{\circ}00'N$ ;  $84^{\circ}37'E$ ), Gorkha, at the households of the farmers. Measurements were taken over 120 days, from June to September, 2006. Katteldana, situated mid-way between Kathmandu and Pokhara, has 550 people and 78 households. It is about 1097 m above sea level, receiving an average annual rainfall of 1537 mm, usually between July and August, and having a minimum air temperature of about  $8^{\circ}C$  in winter (December – February) and a maximum air temperature of about  $32^{\circ}C$  in summer (April-August). According to the municipality at Ghorka Bazaar, at the time of our study, Katteldana occupied 1478 rupani of privately owned land of which 397 rupani were used as paddies, 1049 rupani were non-irrigated but cultivated terraces, 20 rupani were gardens and 20 rupani were pasture. In addition, 8% of the households leased land. Most families in the village raised some goats for meat and 1 to 2 water buffalo for milk. The livestock were maintained in stalls or tethered near the household and were fed with mainly leaves collected from fodder trees and shrubs.

Five fodder trees were collected by farmers for goats at the time of the study: khanayo (*Ficus semicordata*), sal (*Shorea robusta*), kabro (*Ficus lacor*), katus (*Catannopsis tribuloides*) and aap (*Mangifera indica*). Khanayo is used for fodder, in particular for dry and growing

animals, fuel and fruit; sal for fodder, ritual plates, for timber and fuel; kabro for fodder, in particular for lactating and growing animals, fuel, soil conservation and pickle; katus for fodder and fuel and aap for fodder, fruit and timber (Panday, 1982; Regmi, 2003; Magar, 2005). These fodder leaves, which the goats had experienced previous to the study, were collected daily and brought to the animals.

### Goats Used and Fodder Selection

Twenty castrated local Khari goats, 6 to 8 months of age, were selected and divided randomly into four groups of five goats each (initial mean body mass =  $12.8 \pm 0.22$  kg; among treatments  $P = 0.613$ ). Khari is the most common breed in the mid-hills of Nepal, comprising about 56% of the goat population. On average, females first are bred at 311 days weighing 15.4 kg and produce 1.6 kids per kidding. Non-castrated male goats are usually slaughtered at 12 months of age, weighing about 16.3 kg, and castrated male goats at 24 months of age at about 30 kg. Generally, females are slaughtered only if they do not breed or are aged (Uperti and Khanal 1997; Neopane and Pokharel, 2008). The goats were divided among 20 households (that is, each household received one goat) and the offered tree fodder was that collected by each household in traditional manner, with as little interference as possible from the researchers. Up to five tree fodders being collected at Katteldana at the time of the study were offered to the goats at any feeding. The choice of tree fodders was made by the household. Prior to the study, the goats were drenched against internal parasites and dipped against external parasites. Goats on trial were maintained in individual metabolic cages (length = 1.0 m; width = 0.5 m; height = 1.0 m; Fig. 1) that were produced locally from wood and bamboo. The cages, which allowed measurements of non-eaten forage that was offered, were built on 1 m stilts and roofed with corrugated sheeting.

Goats were offered water *randomly*, tree fodder *randomly*, 75 g/d fresh matter (FM) *khole* (a local concentrate mixture consisting of 60% maize grit, 23% rice bran, 15% mustard cake, 1% salt and 1% mineral) and one of four amounts of stylo grass: 0, 120, 360 and 600 g fresh matter. *Khole* was prepared by cooking the various ingredients with water till boiling forming a thickened porridge-like mixture. It offered the livestock at about 85% dry matter content. The goats were tethered in the cage and weighed tree fodder and stylo grass were hung in bundles for the goats to consume. The fodder and stylo grass were offered and

refusals were weighed three times a day (07:30, 12:00 and 17:30) but the *khole* was offered only once in the morning. Each goat was weighed at the beginning, every 15 days thereafter, and at the end of the trial.

#### **Composition and Metabolizable Energy Yield of Stylo Grass and Fodder Trees**

Dry matter content of the fodder and orts was determined by drying in an oven at 50°C until constant mass. Higher temperatures are not recommended because phenolics can be inactivated directly and/or can bind with fibre. In addition, drying samples at 50°C and 80 - 90°C was compared and no difference in dry matter content was found. Samples were analyzed for nitrogen (N) content by the Kjeldahl method and for ash by burning at 550°C (AOAC, 1984). Crude protein was calculated as 6.25 X N. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined as described by Van Soest, Robertson and Lewis (1991), applying a Fibertec System M6 (Tecator, Haganas, Sweden). Condensed tannins were determined using the butanol-HCl iron reagent and results were expressed as leucocyanidin equivalent (Porter *et al.*, 1986; Makkar *et al.*, 1993).

Metabolizable energy yield of the samples was estimated *in vitro* using the Hohenheim Gas method (Menke *et al.*, 1979; Degen *et al.*, 2010a). In this method the gas produced in anaerobic fermentation of substrate is used to predict the nutritive value. Rumen liquor and particulate matter were collected before morning feeding from two goats fed on a roughage diet of mainly poor quality wheat straw and some lucerne hay; And the liquor was homogenized, strained and filtered through glass wool. Incubation media was prepared as described by Menke *et al.* (1979). Samples, each of 200 mg DM, were incubated in triplicate in 100 ml calibrated glass syringes in which 30 ml of the incubation media was added. The glassware was kept at 39°C and flushed with CO<sub>2</sub> before use; And the mixture was continually stirred under CO<sub>2</sub> at 39°C. Gas production, as determined by piston movement, was measured over 24 h after correcting for gas production due to rumen fluid alone.

Gas production (GP, ml/200 mg DM) and crude protein (CP, g/kg DM) were used to estimate *in vitro* metabolizable energy (IVME) yield as follows (Menke *et al.*, 1979; Menke and Steingass, 1988):

$$\text{IVME (kJ/g DM)} = 2.20 + 0.136 \text{ GP} + 0.0057 \text{ CP}$$

#### **Statistical Analysis**

Regression analyses, with both single and multiple independent variables, were done using Statistica for Windows software (StatSoft, Inc., Tulsa, OK), and p<0.05 was chosen as the minimal acceptable level of significance. Single regression analysis was used to test the effect of stylo grass on the intake of total tree forage. Multiple regression was used to determine the relationship between final body mass of the goats and each of the offered feeds. Collinearity statistics was used to evaluate the contribution of each of the independent variables in which tolerances, variance inflation factors, semi-partial correlations and beta coefficients were calculated. Tolerance measures the proportion of variance in the independent variable that is explained by other independent variables in the model. A tolerance of close to one indicates that the independent variable in question is not redundant with other independent variables in the equation. The variance inflation factor is the reciprocal of tolerance and measures the degree to which the interrelatedness of the variable with other independent variables inflates the variance of the estimated regression coefficient for that variable. A value of 1 is ideal in that there is no multicollinearity and a value of 4 is considered the minimum to indicate a possible multicollinearity problem. The squared semi-partial correlation was used to represent the per cent of total variance in body mass explained by stylo grass and each of the tree fodders. Beta coefficient is the regression coefficient after standardizing all the variables to a mean of zero and a standard deviation of one; thus beta coefficients represent the contribution of stylo grass and each of the tree fodders to the prediction of body mass.

#### **Results**

The castrated male Khari goats stayed healthy and gained body mass throughout the 120 day study. Mean initial body mass of the goats was 12.8±0.22 kg and final body mass was 19.9 ± 0.40 kg. Stylo intake ranged between 0.0 and 0.24 of total dry matter intake and between 0.0 and 0.26 of total metabolizable energy intake. Stylo orts for goats offered with 600 g/d FM was higher than that for goats offered with 120 and 360 g/d FM (P < 0.05); And the latter two did not differ. Average daily gain was not significantly different among groups (P > 0.05) and ranged between 53.0 ± 8.1 for the 0 g/d FM stylo grass group and 64.6 ± 5.61 for the 360 g/d FM stylo grass group (TABLE 1).

TABLE 1 CRUDE PROTEIN (CP), NEUTRAL DETERGENT FIBRE (NDF) ACID DETERGENT FIBRE (ADF) ACID DETERGENT LIGNIN (ADL) CALCIUM (CA) PHOSPHORUS (P) AND CONDENSED TANNINS (CT) CONTENTS AND MEATABOLIZABLE ENERGY (ME) OF STYLO GRASS AND FIVE FODDER TREES OFFERED THE GOATS. COMPONENT VALUES ARE IN G/KG DRY MATTER AND ME IN KJ/G DRY MATTER.

Species	CP	NDF	ADF	ADL	Ca	P	CT*	ME
Stylo ( <i>Stylosanthes guianensis</i> )	135.3	539	506	241	16.6	1.0	17.0	5.30
Khanayo ( <i>Ficus semicordata</i> )	106.0	533	482	172	21.9	1.8	87.9	4.87
Sal ( <i>Shorea robusta</i> )	77.2	642	619	260	3.1	1.5	106.0	4.83
Kabro ( <i>Ficus locar</i> )	168.0	577	523	310	16.3	2.2	48.6	5.69
Katus ( <i>Castanopsis tribuloides</i> )	109.9	764	753	342	4.2	1.7	63.0	4.59
Aanp ( <i>Mangifera indica</i> )	73.6	548	532	215	13.6	1.3	74.0	5.12
Mean (S.E.)	112 (35.8)	600 (89.6)	569 (101.4)	257 (62.1)	12.6 (7.46)	1.6 (0.42)	66.1 (31.17)	5.07 (0.392)

\*As leucocyanadin equivalent

TABLE 2. MEAN (S.E.) INITIAL AND FINAL BODY MASSES, AVERAGE DAILY BODY MASS GAIN (ADG) AND AVERAGE FODDER AND METABOLIZABLE ENERGY INTAKES IN KHARI GOATS (N = 5 PER TREATMENT) RECEIVING DIFFERENT FRESH MATTER (FM; G/D) LEVELS OF STYLO GRASS OVER 120 DAYS.

FM stylo offered	0	120	360	600
<i>Body mass</i>				
Body mass, initial (kg)	13.0 (0.38)	13.2 (0.36)	12.6 (0.19)	12.5 (0.73)
Body mass, final (kg)	19.4 (0.74)	20.7 (1.05)	20.2 (0.45)	19.3 (0.80)
ADG (g/d)	53.0 (8.01)	62.5 (6.30)	64.6 (5.61)	56.8 (5.04)
<i>Dry matter intake (DMI)</i>				
Total DMI	547.3 (13.18) <sup>a</sup>	577.7 (16.00) <sup>a</sup>	489.8 (13.15) <sup>b</sup>	542.9 (16.10) <sup>a</sup>
Khole intake (g/d)	62.4 (0.91)	61.3 (0.93)	63.8 (0.25)	62.0 (1.07)
Stylo intake (g/d)	0 <sup>a</sup>	25.8 (0.50) <sup>b</sup>	85.8 (0.58) <sup>c</sup>	131.8 (1.78) <sup>d</sup>
Stylo orts (g/d)	0 <sup>a</sup>	4.5 (0.50) <sup>b</sup>	4.7 (0.49) <sup>b</sup>	19.6 (1.78) <sup>c</sup>
Tree fodder intake (g/d)	484.8 (12.92) <sup>a</sup>	490.6 (15.49) <sup>a</sup>	340.2 (12.92) <sup>b</sup>	349.2 (15.92) <sup>b</sup>
Khanayo intake (g/d)	200.6 (11.69) <sup>a</sup>	285.1 (16.83) <sup>b</sup>	179.5 (12.3) <sup>a</sup>	242.0 (16.44) <sup>c</sup>
Kabro intake (g/d)	6.0 (2.93)	4.5 (2.01)	12.4 (4.43)	7.3 (2.46)
Aanp intake (g/d)	20.7 (7.68)	25.9 (8.43)	16.9 (8.95)	7.7 (4.79)
Katus intake (g/d)	133.0 (13.07) <sup>a</sup>	90.9 (13.53) <sup>b</sup>	80.8 (9.48) <sup>b</sup>	59.3 (13.59) <sup>b</sup>
Sal intake (g/d)	124.5 (14.08) <sup>a</sup>	84.3 (11.82) <sup>b</sup>	50.7 (7.10) <sup>c</sup>	32.8 (6.33) <sup>c</sup>
<i>Metabolizable energy intake (MEI)</i>				
Total MEI (MJ/d)	2.67 (0.062) <sup>a</sup>	2.84 (0.075) <sup>a</sup>	2.45 (0.063) <sup>b</sup>	2.73 (0.075) <sup>a</sup>
Khole (kJ/d)	343.4 (5.01)	337.3 (5.42)	350.9 (1.39)	340.7 (5.89)
Stylo (kJ/d)	0 <sup>a</sup>	136.8 (2.67) <sup>b</sup>	454.8 (3.10) <sup>c</sup>	698.6 (9.44) <sup>d</sup>
Tree fodders (MJ/d)	2.33 (0.060) <sup>a</sup>	2.37 (0.072) <sup>a</sup>	1.65 (0.061) <sup>b</sup>	1.69 (0.074) <sup>b</sup>

Values within rows with different superscripts are different from each other (P<0.05)

TABLE 3. THE EFFECT OF METABOLIZABLE ENERGY INTAKE OF *KHOLE*, *STYLO*, *KHANAYO*, *KABRO*, *KATUS*, *AANP* AND *SAL* (INDEPENDENT VARIABLES) ON FINAL BODY MASS (DEPENDENT VARIABLE) IN KHARI GOATS. INCLUDED IN THE TABLE ARE TOLERANCE, VARIANCE INFLATION FACTOR (VIF), BETA, SQUARED SEMI-PARTIAL CORRELATION (SP), R<sup>2</sup> AND P VALUES OF THE INDEPENDENT VARIABLES.

Variable	Tolerance	VIF	r <sup>2</sup>	Beta	SP	t	P
<i>Khole</i>	0.954	1.048	0.046	0.114	0.111	2.417	0.017
<i>Stylo</i>	0.585	1.709	0.415	0.505	0.386	8.418	0.000
<i>Khanayo</i>	0.591	1.692	0.409	0.657	0.505	11.013	0.000
<i>Kabro</i>	0.719	1.392	0.281	0.121	0.103	2.237	0.027
<i>Aanp</i>	0.686	1.458	0.314	0.392	0.325	7.088	0.000
<i>Katus</i>	0.690	1.450	0.311	0.704	0.584	12.747	0.000
<i>Sal</i>	0.529	1.890	0.471	0.756	0.550	11.990	0.000

### Fodder Composition

Crude protein of the plants ranged between 74 and 168 g/kg DM; And content of stylo was 135.3 g/kg DM, which was lower than kabro but higher than the other four tree fodders. Condensed tannins ranged between 48.3 and 106.0 g/kg DM in the tree fodders, with sal containing the highest content; content of stylo grass, 17.0 g/kg DM, was considerably lower than the tree fodders. Khanayo had the highest calcium content, 21.9 g/kg DM, and sal the lowest, 3.1 g/kg DM. Metabolizable energy yield of the tree fodder leaves offered averaged 5.0 ± 0.21 kJ/g DM; that of stylo grass was 5.3 kJ/g DM (Table 2).

Multiple regressions of the effect of the independent variables, MEI of *khole*, stylo grass, khanayo, annp, katus and sal on the dependent variable body mass (mb) were significant (n = 158; r<sup>2</sup>adj = 0.67; SE of estimate = 1.435; P<0.01) and were used for further analyses. The tolerance of each independent variable ranged between 0.53 and 0.95 and the variance inflation factor ranged between 1.05 and 1.89 indicating very low collinearity among the offered feeds. The squared semi-partial correlation of stylo grass (0.39) and its beta (0.50) were both lower than those of sal (0.55 and 0.76), katus (0.58 and 0.70) and khanayo (0.51 and 0.66) but above those of annp (0.32 and 0.39) and kabro (0.10 and 0.12), indicating that its contribution to the total variance and its effect on mb was lower than the former three tree fodders and higher than the last two tree fodders (Table 3).

There was a significant negative correlation between stylo grass DM intake and tree fodder DM intake. The regression equation took the form:

Tree fodder DM intake (g/d) = 491.2 – 1.223 stylo grass DM intake (g/d) (n = 158; r<sup>2</sup>adj = 0.30; S<sub>a</sub> = 11.7; S<sub>y,x</sub> = 95.9;

P<0.001), where S<sub>a</sub> = SE of the intercept and S<sub>y,x</sub> = SE of the estimate.

### Discussion

We predicted that stylo grass would have a greater effect on body mass of the goats than other tree fodders and that its intake would reduce the intake of tree fodders. Our predictions were partially confirmed. The dry matter intake of tree fodders was reduced with an increase in that of stylo grass, as predicted. Furthermore, dry matter intake of stylo grass significantly affected body mass, also as predicted, but its contribution to the variance of body mass and its effect on body mass were less than the dry matter intakes of three of the tree fodders.

Khari goats are generally reared under a poor nutritional regime, with tree fodders as the main dietary component. Consequently, average daily gain of castrated males in the mid-hills of Nepal is low, ranging between 44 g/d (Kuwar *et al.*, 2001) and 50 g/d Pandey (2008). In this study, average daily gain among the four treatment groups was higher and ranged between 53.0 and 64.6 g/d. The tree fodder dry matter intake decreased with an increase of stylo grass DM intake. This is in contrast to the findings of Phengsavan and Ladin (2003) who reported that growing goats consuming stylo 184 as a supplement to a medium quality grass diet increased feed intake.

There is evidence that there is an optimal amount of stylo grass that should be included in the diet for livestock. Phengsavan and Ladin (2003) tested different levels of stylo grass supplementation (0, 20%, 30% and 40% of expected DM intake) in a diet of growing goats based on Gamba grass and suggested that 30% of stylo grass be included with the basal diet.

Lana *et al.* (1995) reported that live weight of Bali steers was higher with a 50:50 ratio of elephant grass:stylo grass mixture than with 100:0, 75:25, 25:75 and 0:100 elephant grass/stylo grass legume ratios. Furthermore, Pailan *et al.* (2005) concluded that a combination of buffel grass, stylo hay, and subabul leaf meal (40:40:20) improved nutrient utilization of sheep over that of only buffel grass or a mix of buffel grass with stylo hay (50:50). A supplement of 200g/d stylo hay increased in feed intake, utilization and weight gain yearling lambs raised by smallholder farmers (Njwe and Kona, 1994). In this study, the difference in rates of average daily gain among the four treatment groups was not significant, although the goats that received 120 g FM of stylo grass tended to consume the highest amount of metabolizable energy and have the highest body mass at the end of the experiment.

Tree fodders generally have high crude protein but are also high in condensed tannins, which reduce dry matter intake and digestibilities of forages and can be toxic to herbivores (Clausen *et al.*, 1990; Degen 1995, 1997). They form precipitates with proteins, resulting in the formation of indigestible tannin-protein complexes (Makkar, 1993) and form complexes with carbohydrates, cellulose, hemicellulose and amino acids reducing their digestibilities (Makkar, Singh and Dawra, 1987). In addition, tannins react with the protein of the outer cellular layer of the gut, thereby reducing the permeability of nutrients, interacting with digestive enzymes rendering them ineffective (Silanikove, Nitsan and Perevolotsky, 1994) and inhibiting microorganisms resulting in a reduction in the production of gases and volatile fatty acids (Makkar, Blümmel and Becker, 1995). However, low levels of tannins can be handled by ruminants and can have some beneficial effects (Villalba *et al.*, 2002). They can enhance intakes and digestibilities of other dietary components and can reduce the internal parasite load, at least in small ruminants (Min *et al.*, 2004). Sal had the highest condensed tannin and the lowest crude protein contents but its intake was intermediate among all feeds, which was not avoided. Moreover, it explained more of the variance and had the greatest effect on body mass of all fodders, including stylo grass.

The goats in this study were offered with stylo grass and at least two other fodder leaves at each feeding. Several hypotheses have been proposed to explain dietary selection by ruminants (Jansen *et al.*, 2007). Some researchers have proposed "minimization"

hypotheses: ruminants minimize the intake of plants with high tannins and/or other secondary compounds that have detrimental effects and the intake of plants with high lignin content that lower the digestibility (Skarpe *et al.*, 2007). Apparently, this did not occur in this study, at least in the goats offered with 600 g/d FM Stylo grass. It seems that the stylo grass orts of 4.5 to 4.7 g/d DM for goats offered with 120 and 360 g/d FM may have been the minimal amount that could be left due to such reasons as trampling. Stylo grass orts for goats offered with 600 g/d FM was 19.6 g/d and was higher ( $P > 0.05$ ) than these two groups; consuming more stylo grass by these goats which would have reduced tannin intake. Other authors have proposed "maximization" hypotheses: ruminants maximize nutrient intake (Behmer *et al.*, 2002) and/or energy intake (van Wieren, 1996). Yet another proposed option is the satiety hypothesis which, according to Jansen *et al.* (2007), can take into account both the minimization and maximization approaches. In this hypothesis, animals stop eating highly toxic or highly nutritious food due to aversion to food that has just been eaten, and then select other feeds (Provenza *et al.*, 2003). This may have occurred in this study with the stylo grass at the highest level. It is also possible that some fodders are consumed or avoided because of minerals such as calcium, which was the highest in khanayo and phosphorus, which was the highest in kabro. Therefore, slotting dietary intakes according to these hypotheses can be difficult, as they are not exclusive from each other.

## Conclusion

Dry matter intake of tree fodders decreased with an increase in that of stylo grass, and all feeds were able to explain 0.67 of the variance in body mass. Stylo grass orts increased when 600 g/d fresh matter was offered, suggesting that a lower level should be offered to growKhari goats.

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